Biomass and productivity of alpine pasture in Garhwal Himalaya, India

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Abstract: The study deals with the biomass and net primary productivity of high altitude grassland at Gangotri in Garhwal Himalaya. Two sites Tapovan and Nandanvan having similar elevation were taken for the investigation. The vegetation of the region was mainly herbaceous in which species richness was 41 and 35 in respective sites. The value of density ranged from 0.3 to 66.95 plants m^{-2}. Among herbs, the density of *Kobresia royleana* and *K. nepalensis* were the highest as 57.10 to 55.50 plants m^2 on their respective sites. The highest and lowest values of aboveground biomass at Tapovan was 436 and 181 g m^{-2} and at Nadanvan 325 and 130 g m^{-2} respectively. The range value of belowground biomass was 1648 to 2264 g m^{-2} at Tapovan and 1497 to 2251 g m^{-2} at Nandanvan sites. At Tapovan annual net aboveground production was 268 g m^{-2} with highest liveshoot production in August and the lowest in May. In Nandanvan pasture annual net production was 243 g m^{-2} with highest net production in June. [New York Science Journal. 2010;3(2):40-44]. (ISSN: 1554-0200).

Key words: Garhwal Himalaya, Alpine, Phytosociological, Biomass, Primary productivity

1. Introduction

The Garhwal Himalaya is situated on the western aspect of Great Himalayan Range. Alpine pastures in Garhwal Himalaya lie between snowline and timberline. These are the true grasslands in India. There is very harsh condition for survival in this region; the life span of vegetation is generally extends from April to October. These areas remain covered with snow from November to April. This region is known for rich plant and animal diversity, beautiful landscapes, forests, lakes, mountain ranges and alpine pastures. The high altitude pastures locally known as 'Bugyals' are characterized by perennial herbaceous plants, short stemmed vegetation, semi prostrate shrubs etc. This region is inaccessible to the domestic animals. The only Bharal (Wild life) the Himalayan goat live here as grazer. In last few decades some workers have analysed structure, composition, productivity conservation aspects of high altitude Himalayan region (Joshi, 1982; Naithani, 1984). This study belongs to the structure and productivity aspects of high altitudes. The present study was carried out to evaluate the biomass, primary productivity and phytosociological structure.

2. Materials and Methods

2.1 Study Area

Two study sites were located at an elevation of 4400m (Nandanvan) and 4300m (Tapovan) in the district Uttarkashi of Uttarakhand, India. These sites were opposite to each other above Gangotri glacier. Tapovan is the flat terrain while Nandanvan is inclined towards South. These sites remain covered by snow from November onward to April, represented cold desert with sparse vegetation. Vegetation growth starts after snow melting and the growth period extends from May to October. July and August show heavy precipitation, July remain hottest and humid month with mean temperature of 11.6 ^{0}C and with humidity of 92%. The soil on both sites was rich in soil organic carbon (SOC), total nitrogen (N), available phosphorus (P) and potassium (K). The chemical analysis of soil was followed with standard methods Phytosociological analysis was done using 10 randomly placed quadrats of size 50 x 50cm each. The soil analysis and vegetation analysis was followed by standard methods.

Aboveground plant biomass was collected through randomly placed 50 x 50 cm quadrats by harvesting method. Sampling was done in each month from May to October. Belowground biomass was taken from 3 soil monoliths (25 x 25 x 30 cm depth). The aboveground plants were separated into live shoot, dead shoot and litter and weighed separately. Belowground monoliths were washed carefully and dried completely at 80^0 C until constant weight.

Aboveground net primary production (ANP) was determined as the sum of positive changes in biomass in successive months plus mortality (Ram *et al.*, 1989). Belowground primary production (BNP) was estimated as the sum of positive increments in belowground biomass (Rau, 1961). Difficulties and inaccuracies are involved in the estimation of belowground net production because of insufficient information on the periods of greatest root growth and decomposition, unaccounted losses of organic root secretion, sloughing of root hair, root caps and cortical layers, death and decay of fine roots, consumption of roots by soil animals and accumulation of random errors (Rau, 1975).

3. Results

3.1 Soil properties

Chemical properties of soil were analsyed for SOC, N, P, K and pH. The SOC, N, P and K were reported higher at Tapovan site comparatively Nandanvan site. However, the pH values were 4.78 and 5.42 (acidic) in Tapovan and nandanvan sites (Table 1).

Table 1 Chemical characteristics of soil

Element	Tapovan	Nandanvan
SOC (%)	0.45±0.08	0.13±0.09
Total N (%)	0.04±0.007	0.013±0.010
P (kg ha^{-1})	12.41±5.85	6.97±1.34
K (kg ha^{-1})	43.25±15.91	25.65±8.80
pH	4.78±0.10	5.42±0.41

3.2 Analytic characters

Between the Tapovan and Nandanvan sites, a total of 41 plants were recorded at Tapovan and 35 plants at Nandanvan site. *Kobresia royleana* and *Carex nivalis* were dominant and co-dominant species at Tapovan. *Calamogrotis pulchella, Carex obscura, Danthonia cachemiriana* were the plant species in order after dominant and co-dominant. The species belonging to the family Cyperaceae were *Kobresia royleana* and *Carex nivalis* and the grasses of family Poaceae were *Bromus oxydon, Trisetum clarkei, Calamogrotis decora* and *Danthonia cachameriana*. Other herbaceous species on both the sites were *Potentilla argyrophylla, Elsholtzia eriostachya, Primula denticulata, Trigonella emodii, Arenaria festucoides, Pedicularis porrecta, Campanula aristata, Artemisia stricta, Erigeran alpinum* etc.

In the month of August, *Kobresia royleana* was dominant (IVI-59.16) and *Carex nivelis* co-dominant species. *Sibbaldia parviflora* is a spreading herb had the maximum values of IVI (12.52) and density (8.3 plants m^{-2}) among non graminoides.

In the month of August *Kobresia nepalensis* was dominant followed by *Carex obscura* with IVI values of 67.28 and 33.07 respectively. *Sibbaldia parviflora* was dominant among dicoyledons with density (10.05 plants m^{-2}) and IVI (16.68). The least dominant species was *Gentiana tenella* at Nandanvan site.

3.2 Biomass

The above ground and below ground biomass of Tapovan and Nadanvan is shown in Table 2. The highest and lowest values of aboveground biomass at Tapovan was 436 (August) and 181 g m^{-2} (May) and at Nadanvan 325 (August) and 130 g m^{-2} (May) respectively. The range value of belowground biomass was 1648 to 2264 g m^{-2} for Tapovan and 1497 to 2251 g m^{-2} for Nandanvan (Table 2).

The belowground biomass comparatively aboveground was very high. The belowground and aboveground biomass of plants is shown in Table 2.

Table 2 Biomass production (above and below) gm m^{-2} on Tapovan and Nandanvan sites

Months	Above ground	Below ground	BG/AG ratio
Tapovan			
July 2003	305	1872	6.14
August	436	2104	4.82
September	250	2072	7.40
October	230	2264	9.84
May 2004	181	2016	11.14
June	298	1648	5.53
Nandanvan			
May 2005	130	1987	15.28
June	258	1552	6.02
July	269	1497	5.56
August	325	1800	5.54
September	136	2120	15.59
October	144	2251	15.63

3.3 Net production

On Tapovan pasture site annual net aboveground production was 268 g m^{-2} with highest liveshoot production in August and the lowest in May. In Nandanvan pasture annual net production was 243 g m^{-2} with highest net production in June (Table 3).

Table 3. Above and belowground net prouct-ion (g m^{-2} m^{-1}) at Tapovan and Nandanvan site

Months	Aboveground production	Belowground production
Tapovan		
July	-	-
August	131	232
September	-237	-32
October	-47	192
May	20	-248
June	117	-68
Nandanvan		
May	-	-
June	131	-435
July	27	-155
August	85	303
September	-224	320
October	-30	130

ANP=above ground production BNP= below ground production

3.4 Canopy biomass

In the Tapovan and Nandanvan the canopy biomass ranged from 181 (May) to 436 g m^{-2} (August) for Tapovan and 136 (October) to 325 (August) g m^{-2}

Table 5 Canopy biomass (g m^{-2}) at Tapovan and Nandanvan sites

Months	Canopy Biomass
Tapovan	
July 2003	305
August	436
September	280
October	230
May 2004	181
June	298
Nandanvan	
May 2005	130
June	258
July	269
August	325
September	136
October	144

4. Discussion

The high altitude pastures were located on North-West facing slope of Tapovan (4300m) and South-West facing slope of Nandanvan (4200m). These slopes were dominated by the members of a family Cyperaceae. *Kobresia royleana* was the dominant among the species on both the slope in August at Tapovan and Nandanvan sites. Growth initiation on these sites occurred during April-May as snowmelt. From May to June the temperature and rainfall favours the growth activity and perennial tillers belowground plant parts started sprouting vigorously. Most alpine plants of higher altitude are reported to complete their growth cycle within 2 to 4 months (Sims and Singh, 1978). During August to September vegetative growth consequently converted to flowering and fruiting phases. Afterwards sharp decline in temperature and consequent unavailability of water due to frosty conditions stopped the vegetative growth. The freezing conditions after October destroyed the green tissue, and no photosynthesis occurs under snow cover (Singh and Yadav, 1974). (Singh *et al.,* 1984) described that photosynthates are translocated downwards to storage region in the roots and thus help to increase the productivity of belowground parts. The presence of different vegetation at varying topography can be attributed to the difference in the amount of interaction of various climatic factors such as snowfall, rainfall, water potential in the alpine habitat ultimately affects the vegetation composition (Sundriyal *et al.,* 1988; Sundriyal, 1992). The phytomass in liveshoot, standing dead and belowground parts increase according growing season. Variation in soil composition and microclimate are mainly responsible for fluctuation in frequency, density and IVI of species. A few species at each site were unpalatable to grazers. Fluctuation in community structure can be due to heat and light influx on the ground, moisture availability period etc. (Sundriyal and Joshi, 1990; Tieszen, 1974). In grassland community, association between certain species is influenced by site condition, microclimate and topography. The composition and biomass of any ecosystem is mainly controlled by climatic conditions and edaphic characteristics which are related to phenology and floristic diversity. Favourable climatic conditions support the growth of large number of plant species with increasing biomass. On the sites of Tapovan and Nandanvan 36 species were recorded in July and 41 species in August at Tapovan and 33 species in July and 35 in August at Nandanvan sites. Biomass production at Tapovan site showed increasing pattern from May to August, same pattern was observed for Nandanvan site. August onwards the temperature starts decreasing and sharp decrease observed in October. The increase in liveshoot biomass form May to August indicate a favourable conditions for plant growth on both the sites. The peak biomass for individual species showed considerable difference which may be due to variation in phenological behaviors and growth

pattern. Growth in alpine regions started after onset of snowmelt with increase in temperature,

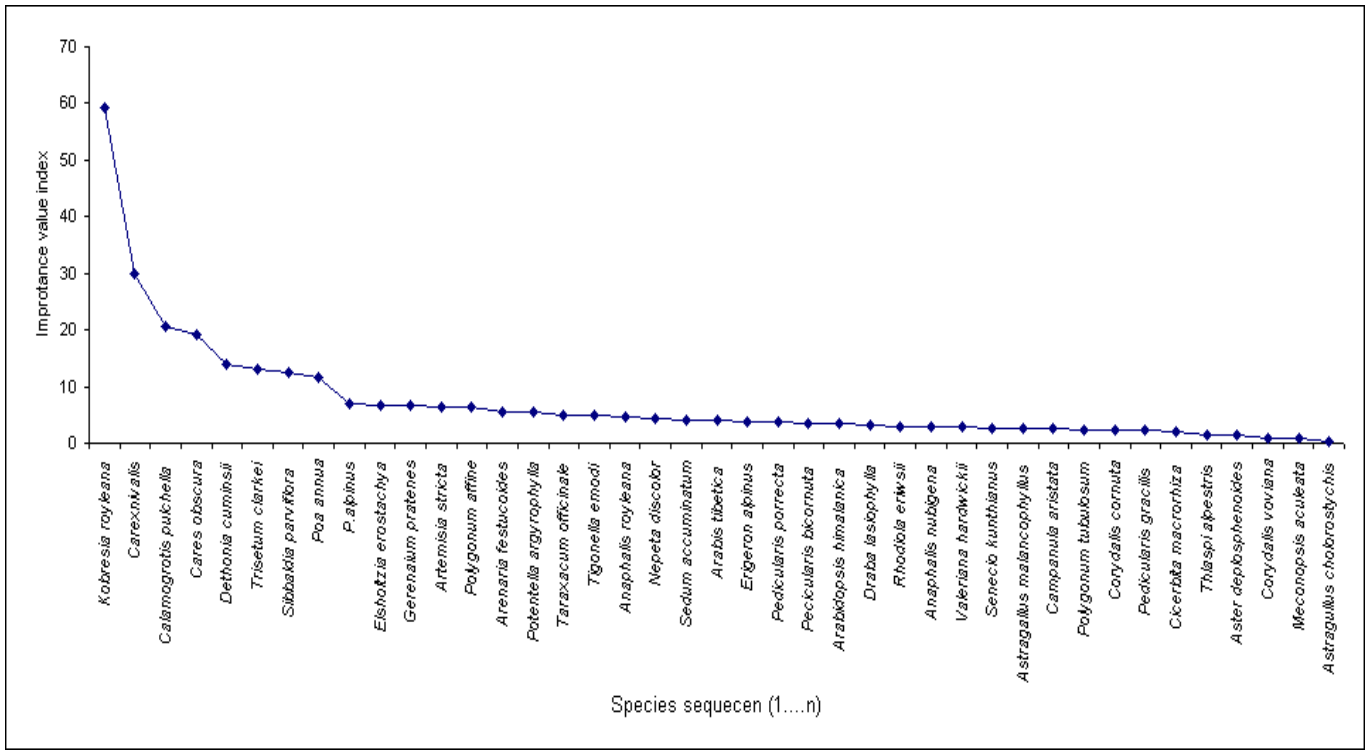

Figure.1 Dominance-diversity cure of species at Tapovan

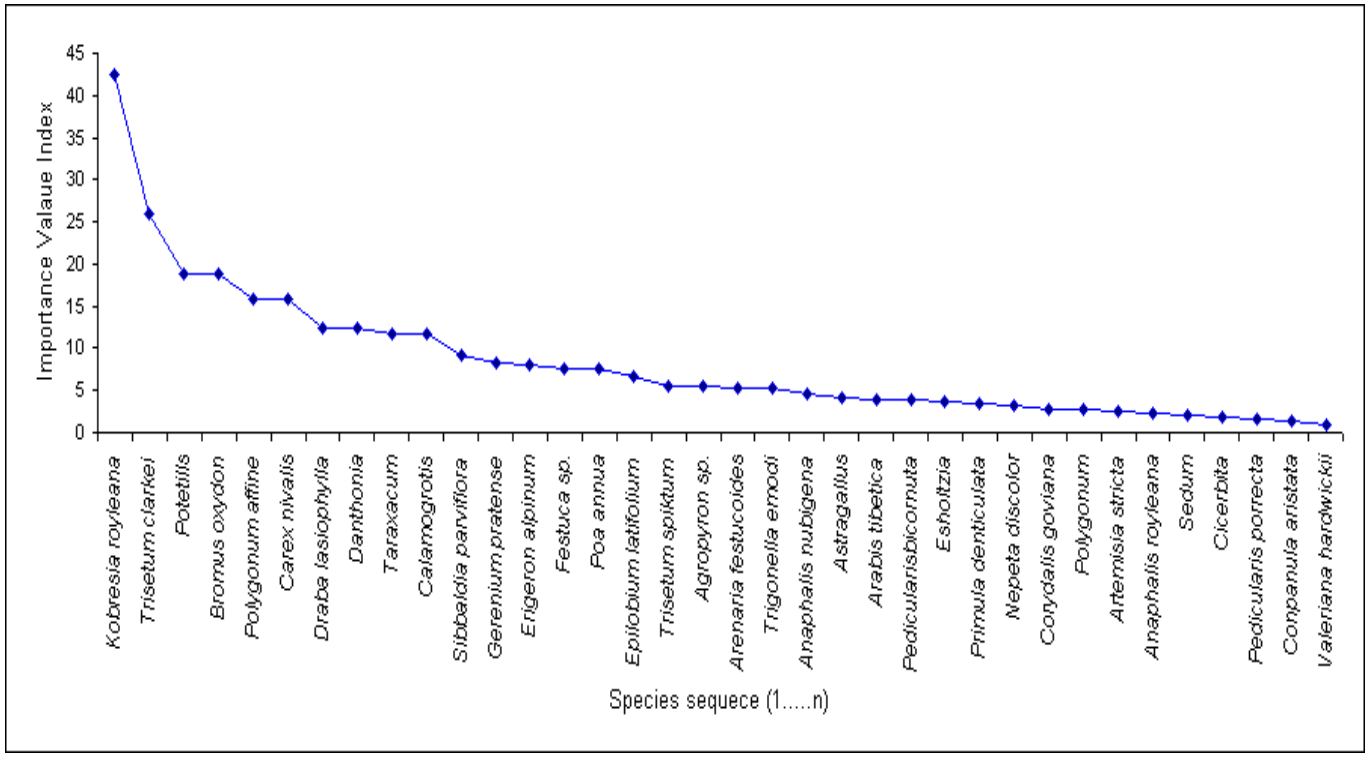

Figure. 2 1 Dominance-diversity cure of species at Nandanvan

while the moisture requirement is supported by the ground moisture after snowmelt. A decreasing trend observed after August due to decrease in temperature and the senescence started in annual herbaceous plants. Decreasing in belowground biomass production was recorded from May to July and for another three months it increases to its highest. Frequency measurements indicate distribution of a particular species. Density measurement emphasizes the importance of a species. Dominance emphasizes a species that consists of a few very large individuals, frequency and abundance measurements emphasize the importance of distribution of individuals belonging to a particular species in the vegetation. IVI is considered as appropriate measure for assessing the overall significance of a species.

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